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GUIDELINES FOR AIR QUALITY MAINTENANCE PLANNING AND ANALYSIS

VOLUME 6: OVERVIEW OF AIR QUALITY MAINTENANCE AREA ANALYSIS

ENVIRONMENTAL PROTECTION AGENCY

SEPTEMBER 1974

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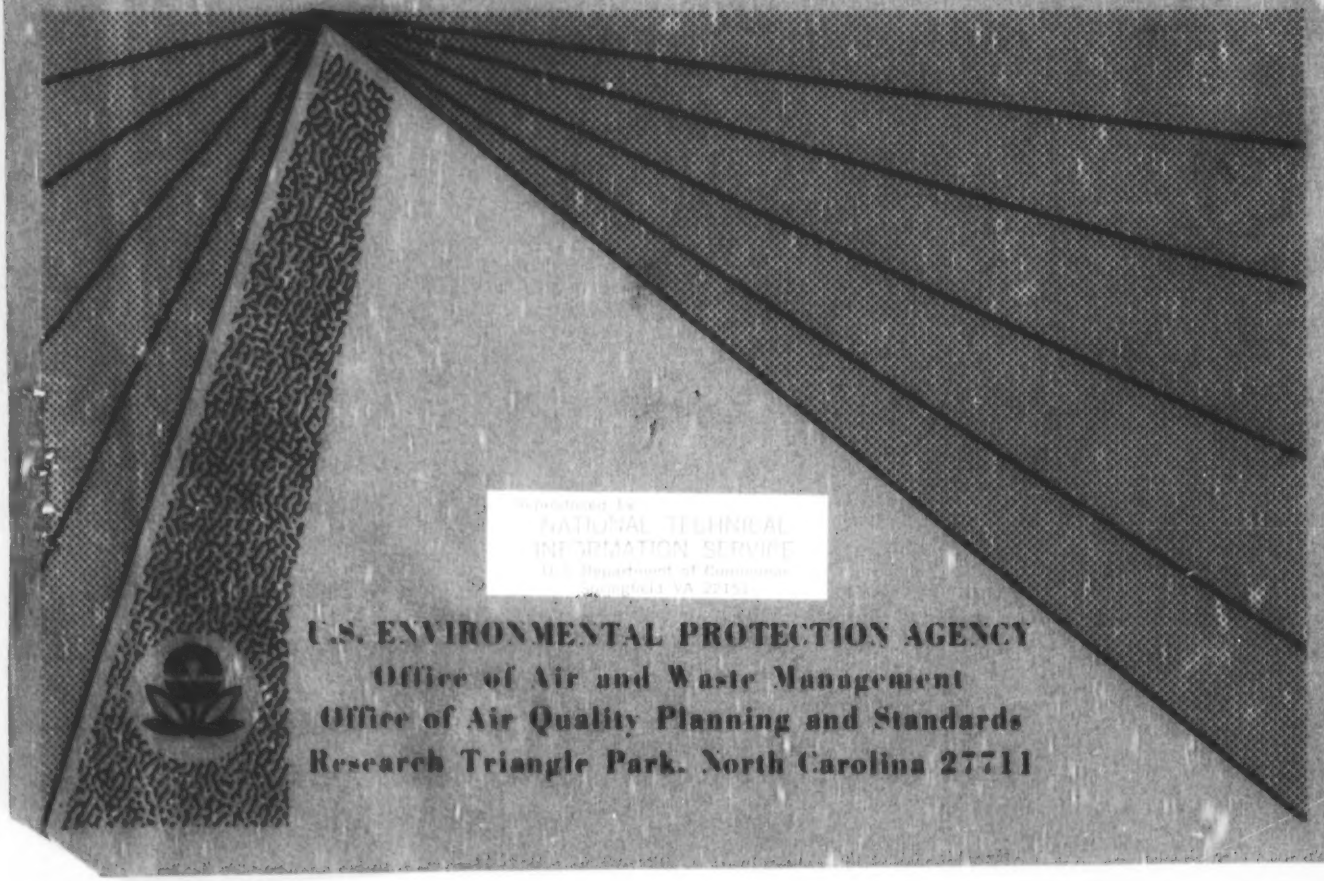

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A description of all the major requirements in analyzing whether an area should be designated as one requiring an air quality maintenance plan and whether a plan is sufficient to meet designated air quality goals, ~~is presented~~. Elements of air quality maintenance area analysis include design and update of emission, meteorological and air quality data bases, use of dispersion models and air quality data to estimate present air quality, projection of future emissions and emission distribution patterns, use of models to estimate future air quality, and assessment of whether control strategies are sufficient to meet air quality requirements in the future.

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September 1974

OAQPS GUIDELINE SERIES

The guideline series of reports is being issued by the Office of Air Quality Planning and Standards (OAQPS) to provide information to state and local air pollution control agencies; for example, to provide guidance on the acquisition and processing of air quality data and on the planning and analysis requisite for the maintenance of air quality. Reports published in this series will be available - as supplies permit - from the Air Pollution Technical Information Center, Research Triangle Park, North Carolina 27711; or, for a nominal fee, from the National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22151.

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FOREWORD

This document is the sixth in a series comprising Guidelines for Air Quality Maintenance Planning and Analysis. The intent of the series is to provide State and local agencies with information and guidance for the preparation of Air Quality Maintenance Plans required under 40 CFR 51. The volumes in this series are:

Volume 1:	Designation of Air Quality Maintenance Areas
Volume 2:	Plan Preparation
Volume 3:	Control Strategies
Volume 4:	Land Use and Transportation Consideration
Volume 5:	Case Studies in Plan Development
Volume 6:	Overview of Air Quality Maintenance Area Analysis
Volume 7:	Projecting County Emissions
Volume 8:	Computer-Assisted Area Source Emissions Gridding Procedure
Volume 9:	Evaluating Indirect Sources
Volume 10:	Reviewing New Stationary Sources
Volume 11:	Air Quality Monitoring and Data Analysis
Volume 12:	Applying Atmospheric Simulation Models to Air Quality Maintenance Areas

Additional volumes may be issued.

All references to 40 CFR Part 51 in this document are to the regulations as amended through July 1974.

NOTE

This guideline is being released in its present form in order to allow its immediate use by State and local agencies. This guideline may be reissued in the near future in order to incorporate comments and suggested improvements offered by the EPA Regional Offices and by State and local agencies and other concerned groups.

PREFACE

The purpose of Volume 6 is to present an overview of the role of analysis in designating air quality maintenance areas, in determining whether a maintenance plan is needed and in evaluating whether a proposed plan is sufficient to avoid exceeding ambient air quality standards. Volume 6 presents a brief discussion of the several elements needed for a complete analysis. Elements of analysis required to estimate present air quality include the present emission inventory, air quality data base and meteorological data base which may be used in atmospheric simulation models of varying complexity. Model estimates are used to supplement the observations obtained by monitoring to assess present air quality. Additional elements needed to estimate future air quality levels are the projection and allocation of changes in emissions which may result from implementation of various air quality maintenance plans or by default. Projected future levels of emissions must be related to future air quality using atmospheric simulation models.

Next, the roles played by the various elements of analysis in assessing the need for an air quality maintenance plan and in the formulation of such plans are discussed more specifically. Finally, a synopsis of the Volumes in the Guidelines for Air Quality Maintenance Planning and Analysis which deal specifically with analysis (i.e. Volumes 7-13) is presented. Interrelationships among the contents of each Volume are described in terms of previously discussed relationships among the elements of analysis.

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1.0 INTRODUCTION

Air quality analysis is concerned with estimating quantitative answers to the following questions:

1. What is the present distribution of emissions?

2. What is the present distribution of pollutant concentrations?

3. What is the relationship between pollutant emissions and concentrations?

4. How are total emissions within the area of interest likely to change due to alternative rates of growth and development, alternative emission control regulations and incentives, and alternative land use and transportation plans?

5. How are emission patterns likely to change?

6. What pollutant concentrations are associated with those alternative emission distribution scenarios?

7. How might emissions be limited in order to stay within the set of compatible emission distributions?

8. How shall the impact of proposed new stationary point or indirect sources be related to air quality goals?

These questions lead to three general analytical activities:

(a) the development, maintenance, and improvement of the data base and techniques for relating the data to present air quality (questions 1-3);

(b) the description of probable air quality given an emission scenario (questions 4-6); and

(c) the prescription of a set of emission distributions given an air quality goal (questions 7 and 8).

Activity (a) includes measurement of pollutant concentrations, emissions, regional meteorology and development of models relating concentrations to emissions for various meteorological conditions. Models are then tested against measured conditions to see how well they work (validation), adjusted in order to maximize their accuracy (calibration), and improved when new or better data indicate that such improvement is desirable and possible.

Activity (b) involves the application of the model to alternative emission patterns so as to estimate their air quality implications. Elements of this activity usually include some emission projection and manipulation prior to the application of the model. Typically, the present emission inventory may be altered by estimating the effects of emission control and new source development. Appropriate, available models may then be applied to estimate the air quality (or change in air quality) associated with the new emission inventory (or change in the emission inventory). In other words, Activity (b) involves the use of models to make a series of "if--then" statements which estimate the air quality associated with emission scenarios.

In performing Activity (c) models are applied in reverse to derive a set of emission patterns which are compatible with a given air quality goal or standard. This compatible set defines limits within which the emission pattern must lie if the air quality goal or standard is to be achieved and/or maintained. Some of the emission patterns in the compatible set will be unrealistic, so a thorough

presceiptive analysis would proceed to narrow the possibilities by excluding those patterns that are incompatible with social, economic, and technological realities even though they would produce acceptable air quality. Realistic patterns can only be derived after thorough coordination with personnel and agencies responsible for other aspects of the area's economic and social welfare. This requirement is needed because emission limitation and allocation impacts on both the rate and form of land use and transportation development, and these, in turn, affect property values, economic development, and future expectations. Furthermore, air quality is not the only environmental consideration which constrains the form and/or intensity of development. Other forms of pollution (water, noise, solid waste) and a host of resource conservation issues are involved in the planning and management of the future. While air quality constraints and constraints imposed by other environmental requirements may be supplied piecemeal, the technical, legal and managerial task of learning to live within these constraints requires unprecedented coordination among the many groups in the public and private sectors which influence development trends.

2.0 ELEMENTS OF ANALYSIS

Elements of analysis include development of a current emission inventory, projection of future emissions and hypothetical emission patterns, measurement and interpretation of air quality data, measurement and interpretation of meteorological data, use of an inventory and measured data to construct and calibrate appropriate atmospheric simulation models, and use of models to project future air quality

associated with projected emissions.

2.1 The Emission Inventory

The emission inventory is central to any air quality control program, for the only practical means for altering air quality is by the limitation, reduction, and redistribution of emissions. The inventory is used to identify the sources of emission, to formulate control strategies, as a base from which to construct future emission scenarios and as a principal input to atmospheric simulation models.

An emission inventory is constructed from a source inventory, emission factors and supplemental source inquiry. The source inventory consists of a list of the number, size, location and (in the case of large sources) emission release characteristics affecting the height of a source's effluent. Only "point sources" are listed individually. A point source, for purposes of diffusion modelling, is defined as one which emits over 100 tons/year of any pollutant. The numerous small sources are listed collectively as area sources. They may be aggregated on a county basis or disaggregated to a network of grid squares within counties using such schemes as the Computer Assisted Area Source Emissions Gridding Procedure (CAASE).[2]

Emission factors are used to estimate the emissions from a source or aggregation of sources given the source type, size, process, number, or other relevant indicator of activity level. Since it is impractical to measure the emission of each and every emission source, emission factors are frequently used to estimate emissions from a

source, given certain of the source's design and operating characteristics. These factors are developed by measuring emissions from representative sources of a given type and using the assumption that similar sources will emit at similar rates. Emission factors are compiled, published, and updated in "Compilation of Air Pollution Emission Factors," AP-42.[3]

Nationwide emission factors are, of necessity, typical or average values. Direct measurement of emissions, inquiry of sources as to their emissions, process, process rate, emission control equipment, etc. are desirable, especially for large sources, to supplement the use of emission factors. The use of specific known emission data for a source is, of course, preferable to use of generalized emission factors.

Growth, attrition, modification and emission control continuously alter the emission pattern and require frequent, periodic updating of the emission inventory. A systematic process for inventory update not only maintains a relevant inventory, it also develops, over a period of time, emission and development trend data on which short range emission projections may be based.

2.2 The National Emission Data System

The wealth of detail inherent in an emission inventory and the diverse forms in which data are retrieved from the inventory suggest automatic data processing. A format for data collection, storage, manipulation and retrieval called the National Emission Data System (NEDS) has been developed by EPA.[1] The NEDS system serves as: (1) a central storage center; (2) a service to state and local agencies; (3) an organizing system for the collection, modification, and updating

of emission inventories; (4) a base for National and sub-National emission projection; and (5) the basic data set for formulating National air pollution control strategies and for approving and monitoring State Implementation Plans. It should, then, be obvious why EPA insists that all emission inventories be kept in common format and why a National Emission Data System has been developed.

2.3 Inventory Projection

Longer range forecasting of emissions involves the estimation of the number, type, and location of new sources, the attrition and modification of existing sources, and the emission factors applicable to both existing and new sources. These estimates are then used to alter the existing or base emission inventory.

The estimation of the direction, rate, and form of future changes must account for inertia, design, and chance. Inertia is the tendency of past trends to continue into the future. The strength of this factor depends on the persistence and uniformity of the historical record. Design is the deliberate prescription and/or limitation of development patterns, rates and practices through regulation and incentive. The design factor limits, enhances, or redirects the trajectory of past trends. Chance includes all those unknown and unexpected factors which influence the future. The probable effects of some chance factors may be able to be described statistically by noting the variance in past trends; others can be limited by design. But forecasting in the social sciences is beset

with a large residue of chance factors which are essentially unpredictable.

The variance in the projected trajectory of past trends and the possibility of altering the probabilities of various trajectories through design lead one to speak of the future in terms of scenarios--chains of possible events leading to alternative futures. These scenarios are more like recipes than predictions. They say, in effect, "Here is a set of possible futures; if you like (don't like) one or more of them, then insure that the chain of events leading there will (will not) occur."

An important set of scenarios results from the projection of past trends and current designs under the assumptions of no new design and no major disruptions. These scenarios represent the range of "expected" future conditions. They are useful in deciding whether intervention (new design) into expected trends is desirable (i.e. whether an air quality maintenance plan is needed), and as a starting place for intervention strategy formulation. The user of such projections should, however, be continuously aware of two caveats:

1. There is not one "expected" future. The trend data upon which the projection is based has some variance. The further into the future the projection goes, the greater is the spread or range of the projection. It is the fringes of this range that should be critically examined for acceptability, not the mean.

2. The "expected" future and its variants comprise only one subset of the possible futures. If the "expected" future is

treated like a prediction to be accommodated rather than a scenario to be evaluated, the result may be a "self-fulfilling prophecy."

The foregoing discussion of forecasting may be summarized thus: the analytical tools for predicting the future are useful but dull; they can narrow the range of possibilities but cannot pinpoint what will, in fact, happen. The emission inventory can be projected a few years into the future with some confidence by noting growth trends, compliance schedules, and approved building permits. Beyond that, the type, number, and especially the location of new sources becomes increasingly difficult to predict.

2.4 Air Quality Measurement

Both the amount of emission control needed and the progress of a control program are indicated by actual measurement of pollutant concentrations in the ambient air. The word "indicated" is used advisedly, for air quality cannot be directly measured at all places and times, and the confounding factor attributable to changing meteorology frequently complicates the interpretation of air quality data. The use of monitoring data to estimate the spatial-temporal distribution of pollutant concentrations must nearly always be supplemented by the use of atmospheric simulation models.

The air quality monitoring and data system serves several functions:

- Initially, it is the sole indicator of air quality.
- It is used in conjunction with the emission inventory and meteorological data to select, and calibrate regional atmospheric simulation models.

. Once models are available, the air quality data serve as a check on the accuracy and validity of the models and provide a means for improving them.

. Where the legal acceptability of model estimates is questioned, the measured air quality data provide supporting evidence.

. The monitor readings and the model estimates together allow the estimation of the component of concentration due to natural and extra-regional sources, and allow one to draw inferences about air quality between monitoring sites.

Not only is it impractical to measure air quality every place, but it is often inconvenient to measure it all the time. The air quality monitoring network may be supplemented by a temporal distribution model as well as by diffusion modeling. It has been observed that pollutant concentrations generally are distributed log-normally in time.[4] This observation allows estimation of the frequency of occurrence of various levels of concentration from sample measurements. In other words, the log-normal model can be used to fill in the temporal blanks in the same way that diffusion models fill in the spatial blanks between monitors, provided there are at least some representative monitoring sites operated continuously which can be used to estimate the standard geometric deviation of air quality data in the area.

It will frequently be desirable to include mobile as well as fixed monitors within a monitoring system. Mobile monitors might be applied to the following situations:

. To determine concentrations around the site of a proposed large point or complex source as part of an environmental impact statement or pre-permit investigation.

. To expand the areal coverage obtainable from a limited number of monitors.

. To spot check on model estimates which appear too high or low, or are legally disputed.

. To check local concentrations around existing large point sources.

. To check CO concentrations near existing points of high traffic density.

2.5 The SAROAD Air Quality Data System

The large quantity of data taken by a monitoring network and the several statistical analyses and summaries routinely performed on the data suggest automatic data processing and storage. The Storage And Retrieval Of Aerometric Data (SAROAD) system has been developed and should be used for this purpose. Detailed description of the selection, placement and operation of monitors, and of the SAROAD system has been documented in several EPA publications.

2.6 Meteorological Measurement

The capacity of the ambient air to assimilate wastes without adverse effect depends on the atmospheric dilutive capacity. This capacity can vary over a wide range with time and location; therefore, it is highly desirable that meteorological conditions be

specified when estimating the relationship between emissions and the resulting concentrations.

Principal meteorological variables affecting air quality include:

(1) Wind speed. The more air that moves by a source of emissions, per unit of time, the less the concentration (mass/volume) will be.

(2) Wind direction is obviously important in estimating the location of concentration relative to the location of emission sources.

(3) Atmospheric stability is a composite variable describing the turbulence, and therefore the dispersion rate, of the atmosphere. The lapse rate (the rate of temperature change with height) is an important indicator of stability.

(4) Mixing height is defined as the height above the surface through which relatively vigorous vertical mixing occurs. It is commonly identified as a layer of the atmosphere with a temperature lapse rate conducive to strong mixing, "capped" by a temperature inversion (temperature increases with height) which restricts such mixing. A low mixing height restricts the volume of air throughout which emissions within the layer may be dispersed. It is often associated with high ground-level concentrations.

Several other meteorological variables are of interest in special circumstances. Temperature affects air quality indirectly by influencing the rate of emissions resulting from the demand for space heating and air conditioning. Humidity and solar radiation intensity are important to the rates of certain atmospheric reactions (formation of oxidants, sulfates, aerosols).

Variations in meteorological conditions for an area can be described with several levels of precision. The level of precision depends on the amount of data available. In general, descriptions of meteorological variations involves four levels of detail. At the least detailed level, meteorology variation is ignored by assuming that worst case conditions will be duplicated annually. The next level of precision assumes that measured conditions at a nearby airport or U.S. Weather Service station are similar to conditions over the entire region. The third level is attained when conditions in a particular area are measured in detail. This is especially important in areas where interactions of specified sources and their immediate surroundings are of interest. Finally, the three dimensional wind field over the region may be estimated. This requires numerous meteorological monitoring sites and the use of various theoretical concepts such as mass balance, conservation of momentum, etc.

Since the siting of instruments and the interpretation of data frequently are dominated by local influences on the important meteorological parameters it is not feasible to give simple, universally applicable guidance on this important subject. It is suggested that the services of a competent meteorologist be obtained to assist in this portion of the analysis.

2.7 Atmospheric Simulation Models

The fundamental question in air quality management is: How can air pollution be reduced/limited? The intuitively obvious answers

are: (1) reduce/limit emissions, (2) raise the height of emission, (3) move emission sources farther away (spread them out), and (4) curtail/prevent emissions when meteorological conditions are especially conducive to high concentrations. These qualitative prescriptions indicate the direction of measures for improving and maintaining acceptable air quality, but are insufficient for the development of strategies for a specific reduction in concentration, maintenance of concentrations below specified levels, or estimating the effects of particular emission sources and measures to control them. In order to estimate the effect of proposed measures and to justify the expense of implementing those measures, the quantitative impact on air quality that will be achieved by a specified change in emissions and/or conditions of emission release must be estimated. A mathematical relationship connecting cause and effect in this manner is called a model. Models may be used in four ways to support air quality and management programs:

1. Atmospheric simulation models may be used in conjunction with measured air quality to estimate the current air quality distribution.

2. Some model must be used to estimate the change in present air quality which would be effected by a projected or hypothetical change in the quantity and distribution of emissions.

3. Some model must be used to estimate the change in the air quality distribution which would be effected by the addition of a proposed new source to the emission inventory.

4. Available models and their data requirements should be

used to rationalize the selection of data improvement projects. Indeed, improvement of the accuracy and detail of the modeling capability is a major purpose of the data upgrade program.

Generally, models which are able to provide air quality estimates having the most detailed temporal and spatial resolution also require the most detailed emission and meteorological data bases. The availability of models which can be used to reliably estimate in detail spatial and temporal variations in pollutant concentrations greatly increases the number of air quality management schemes which can be examined explicitly. Thus, it would be possible to distinguish between two proposals resulting in the same overall amounts of emissions but having different source configurations. The ability to estimate air quality with a fine degree of temporal and spatial detail has important implications on the responsibility to maintain adequate air quality, because it enables the analyst to examine a great many more cost-effective and less socially disruptive control strategies explicitly. The benefits accruing with these increased analytical capabilities provide a strong incentive for maintaining and improving emission inventory, meteorological and air quality data bases in order to improve modeling capabilities.

3.0 AIR QUALITY ANALYSIS AS APPLIED TO AIR QUALITY MAINTENANCE

The air quality analyst has five general tasks associated with air quality maintenance (AQM). The first is to develop and implement a procedure whereby the emission inventory, meteorological and air quality data bases can be routinely improved and updated. Such a

procedure provides a means for determining whether previously projected growth and development is, in fact, occurring, and an increasingly better capability for estimating present air quality as well as that likely to occur in the near future. The second task is the collection and periodic evaluation of the current air quality data to see how well air quality is, in fact, being maintained. The third task is a projection, performed at five year intervals (at least), to estimate whether the combination of new emissions due to general growth and development, and expected emission reductions of existing sources, could lead to unacceptable air quality during a 10-year projection period. The fourth task is assistance in formulating an emission limitation and allocation process which will insure that air quality standards will be maintained. This task is not required unless the projection indicates a reasonable probability that a National air quality standard could be exceeded in the projection period. The final task is the analysis of proposed new point and indirect sources to see if any air quality standard would be exceeded if their emissions were added to the emission inventory or as the result of inadequate design and operating procedures at the proposed source.

3.1 Update of Emission Inventory, Air Quality and Meteorological Data Bases

Efforts should be made to initiate and implement a routine reporting procedure whereby emission estimates from existing

sources can be checked and updated as necessary. Similarly, emission reporting requirements from new sources should be linked as closely as feasible with existing requirements for construction and operating permits so that the emission inventory will reflect the current state of affairs as well as possible. To facilitate inclusion of new data in automated data processing procedures and to aid in the periodic reevaluation of emission projections, it is highly desirable that the new information obtained from the reporting procedures described above be recorded in a standardized fashion (i.e. NEDS format). Inclusion of the latest available emission information will greatly assist in estimating current air quality accurately.

Initial application of models to estimate air quality should identify the most urgent needs for air quality and meteorological data in the area. Such an analysis should serve as the rationale for improving these data bases in a systematic fashion within the constraints imposed by the resources available for monitoring.

3.2 Estimates of Current Air Quality

The success of existing air pollution control programs and the ability to accommodate new emission sources in the region are measured by the historical record and present state of the air quality distribution. Furthermore, the detail and accuracy with which the other AQM tasks are performed depend on the detail and accuracy of periodic air quality distribution estimates. So the performance of this task and the improvement of the tools needed to carry it out should receive serious and regular attention.

The analyst should be in a position to answer five questions about the air quality distribution: (1) what is it now? (2) how has it changed in the past several years? (3) how has it responded to changes in the emission inventory? (4) what is the present relationship between the emission inventory and the air quality distribution? and (5) how would it be changed by a change in the emission inventory? Questions 1-3 can be answered with the records of emissions and concentrations from the emission inventory and monitoring network. The answers to questions 4 and 5 require the use of models.

The next step, then, in AQM analysis, after provision for routine updating and improvement of emission air quality and meteorological data, is the assembly of the emission, inventory, monitoring data and meteorological data, and the selection and exercise of the best models that the quality of that data will support, to determine the present air quality distribution, in space and time, for the baseline year.

In many areas, the state of the emission inventory, monitoring network, meteorological data, technical expertise and computing facilities will not allow the use of other than very simple models for the first (1975) AQM iteration. It should be recognized that simple models limit the accuracy and detail of the analysis, and also limit the strategy options that can be considered if a SIP revision for AQM is necessary. For example, the effects of alternative emission patterns resulting from land use and transportation options cannot be evaluated unless a model is available that will accept emission location as an input. It is particularly important that

improvement of atmospheric simulation modeling capability, and the data quality improvement that it implies, be major objectives of the air pollution control agency.

3.3 Air Quality Projection

The constraints on emissions, existing emissions, and capacity of the atmosphere to assimilate new emissions should be known to developers and land use/transportation planners in all urban areas so that development patterns leading to unacceptable air quality are not proposed or accepted.

The assessment of future air quality potential is done in two steps. The first is the application of quick-look procedures, as given in "Guidelines for Designation of Air Quality Maintenance Areas," OAQPS No. 1.2-016. The second step is a more thorough analysis of the air quality potential for the purpose of assuring that a SIP revision for maintenance is really necessary and for describing the nature and extent of potential air quality problems.

The more thorough analysis to determine whether a maintenance plan is needed is, in turn, divided into 4 steps:

(1) Estimation of current air quality, as described in the previous section;

(2) Projection of county-wide emission growth potential;[9]

(3) Allocation of projected emissions on a subcounty basis;[10,11]

(4) Application of projected emission data in atmospheric simulation models to estimate future air quality levels.[12]

Depending on the sophistication and spatial resolution of available models, it may be possible to by-pass step (3). For example, the disaggregation of projected county non-methane hydrocarbon (NMHC) and NO_x emissions may not be necessary for the 1975 analysis if models capable of estimating the effect of small emission pattern changes on oxidant and NO_2 concentration distribution are not generally available. This is not to say that the location of these emissions makes no difference, but rather that the difference cannot presently be quantified. Models capable of accepting NMHC and NO_x emission patterns should be available by 1980 or sooner, so the preparation of a gridded emission inventory for non-methane hydrocarbons and NO_x should be a goal of the emission inventory upgrade program.

If the analysis uses a model which accepts source location as an input, then urban planners should be consulted to select a probable worst case distribution of projected emissions. Remember that the AQM analysis is to establish only whether a reasonable probability of NAAQS exceedance exists through 1985 without further constraints on land use or transportation or more stringent emission regulations. Therefore, the projection is concerned with what <u>could</u> happen, not what will happen.

It is prudent to repeat at this point that a projection is not a prediction. The probable worst case projections asked for in the analysis phase of the AQM process are scenarios which need not occur.

3.4 Analysis in AQM Plan Formation

The SIP should contain a set of legally enforceable measures

which restrict the rate and distribution of emissions from mobile and stationary sources so that the air quality distribution remains within acceptable limits. Under the Clean Air Act "acceptable limits" are presently defined by Primary and Secondary NAAQS. In the case where Secondary NAAQS cannot be attained in the near-term future due to the lack of appropriate fuel or control technology for existing sources, attainment of Secondary NAAQS may be programmed for a more distant date. Regulations relating to "significant deterioration" may, in the future, prescribe acceptable limits more stringent than secondary standards for TSP and SO_2.

In any case, the SIP must show how the pollutant concentration limits are to be related to emission limits, and how the emissions are to be maintained within those emission limits.

The analytical tools for developing the SIP Revisions will have been explicated during the AQM analysis. These will be: an updated emission inventory, air quality and meteorological data, models based on current and historical data, projections of future development, emission estimates for existing and expected sources, and projected air quality. The results of this analysis will have shown that the potential amount and distribution of emissions of one or more pollutants are not consistent with secondary air quality standards through 1985 (otherwise a SIP revision (AQMP) would not be needed). The analytical tasks associated with SIP revision are: (1) to use the available models to

explore the emission distributions that would be compatible with acceptable air quality objectives, (2) to suggest feasible emission limitation measures for maintaining emission distributions within the compatible set, (3) to test suggested measures against the air quality objectives using available models, (4) to assist land use and transportation planners in defining the air quality constraints on those activities, (5) to develop a periodic air quality assessment program for monitoring the effectiveness of the SIP, and (6) to maintain a program for updating and upgrading the data and models needed for the foregoing tasks.

Each of the above tasks has been discussed earlier and is discussed in detail in Volumes 7-13 in the Guidelines for Air Quality Maintenance and Analysis series. The remaining discussion will be devoted to the role of analysis in selecting certain strategic and tactical options which may be features of an air quality maintenance plan.

3.4.1 Air Quality Maintenance Strategies

Technically, there is only one AQM strategy, and that is to keep the emission pattern within the acceptable set. This requires a knowledge of what the acceptable set of emission patterns is (through the use of valid atmospheric simulation models), the authority to deny building or operating permits which would produce an emission pattern outside the acceptable set, and the will to use that authority.

While numerous emission patterns may be compatible with AQM, their effects on land use potential--who gets to emit how much

and where--may differ substantially. The principal difference between alternative AQM strategies is the way they address distribution problems--such questions as the land use, property rights, development pattern and development rate.

Numerous approaches to AQM are conceivable, but three will serve for illustrative purposes. These may be called accommodation, specification, and flexible. The accommodation strategy temporarily avoids the distributional AQM problems by pushing them into the future. This is done by requiring sufficient reduction of existing emissions (through technological innovation, attrition, etc.) to compensate for expected new emissions for a given time period (e.g., 5 years). No consideration is given to the spatial and temporal distribution of emissions.

The specification strategy approaches the distributional aspects of AQM directly. A specific emission distribution pattern is selected from the acceptable set and imposed directly on the land through emission density zoning and vehicle density limitations. The pattern selected is not the prerogative of the analyst, but of the public and planners.

The flexible strategy represents the broad middle ground between the previous, extreme strategies. The emissions from proposed new construction and land development projects are added to the existing emission inventory and the result is tested for compatibility with AQM using emission-air quality models. Both expected reduction in

existing emissions and land use/transportation plans may also be considered during the new project impact analysis. A necessary condition for construction permit approval is the estimation that the emission pattern would remain within the acceptable set. Sufficient conditions for permit approval should include conformity with other land use/transportation plans and restrictions.

The type of strategy selected depends, on the public acceptance of the constraints necessary to carry them out and on the analytical capabilities which exist in the air quality maintenance area. Generally, the accommodation approach requires the least analytical sophistication, while the specification strategy requires not only a sophisticated approach, but a great deal of confidence in the approach as well.

The accommodation strategy was incorporated in the initial SIPs. Needed emission reduction was identified and required in the SIPs to reduce existing (1970) concentrations plus the increases in those concentrations expected due to growth of emissions in the 1970-1975 period to levels which were consistent with NAAQS. AQM could be approached by a series of such 5 year plans. One problem with this approach is the "moving target" presented to large, existing sources in order to accommodate future growth. The installation of new, more efficient control equipment at frequent intervals would be both disruptive and expensive. Another problem involves long-range major land use and transportation planning projects. A five, or even ten, year time horizon is too short for major land use and transportation planning. A third problem with this strategy is that the model on which it is based (proportional rollback) ignores location of emissions.

The specification approach occupies the opposite end of the spectrum of strategies. In order to choose one of the many emission patterns from the compatible set identified analytically, great confidence must exist in the accuracy of predicting air quality from emissions and in predicting future social, economic, and technological desires and capabilities. Such confidence is presently lacking. Nevertheless, there is a powerful reason for attempting to develop the analytical capabilities to make such a strategy feasible. In order to avoid the obvious equity problems involved in a first-come-first-served allocation of emissions, emission rights could be assigned to the land as part of the zoning restrictions on that land, and land use. Transportation routes, and transportation models could be designed to be consistent with each other, land use requirements and with AQM. A utopian goal? Certainly the analytical techniques needed to define the "optimum" combination of planning elements, including AQM, is utopian. However, if total emissions in a region must be limited, then some rational and equitable method of allocating those limited emissions to potential "users" must be selected or else the allocation will probably be irrational and inequitable. The allocation of emission ceilings to the land does involve difficult decisions as to which land receives which ceilings, but so does any other method of distributing a limited quantity of emissions.

The difficulties of predicting future events, conditions and capabilities lead to the desirability of a flexible process for AQM rather than a static plan. Such a process is also suggested by

the multiplicity of emission patterns compatible with AQM. If models are available which can test the compatibility of a large proposed new source, or a major development or rezoning request for AQM compatibility, then the process approach to AQM can be implemented. A diagram of the "flexible process" approach and the role of analysis in such an approach is shown in Figure 1.

The key feature of the flexible AQM process is the building permit. One condition for permit issuance would be compatibility of the proposed construction with AQM considerations. Those considerations would include, at a minimum, the calculation of the combined air quality impact of the proposed and existing emissions and the assurance that air quality limits would not be exceeded. A second consideration, closely related to land use/transportation planning, would be that the proposed source was the type desired in that location and that its emissions would not preclude other development likely or desired in the vicinity. In order to avoid saying "no" to valuable development due to prior commitments, some advanced planning is clearly necessary.

3.4.2 Air Quality Maintenance Tactics

Tactics may be thought of as the means by which maintenance strategies are implemented. Six types of emission control tactics include: (1) source category emission standards, (2) fuel quality standards, (3) emission disincentives (charges, taxes), (4) land-based emission limits, (5) supplementary controls (stack height, time variable emission limits), and (6) indirect tactics (land-use pattern, transportation

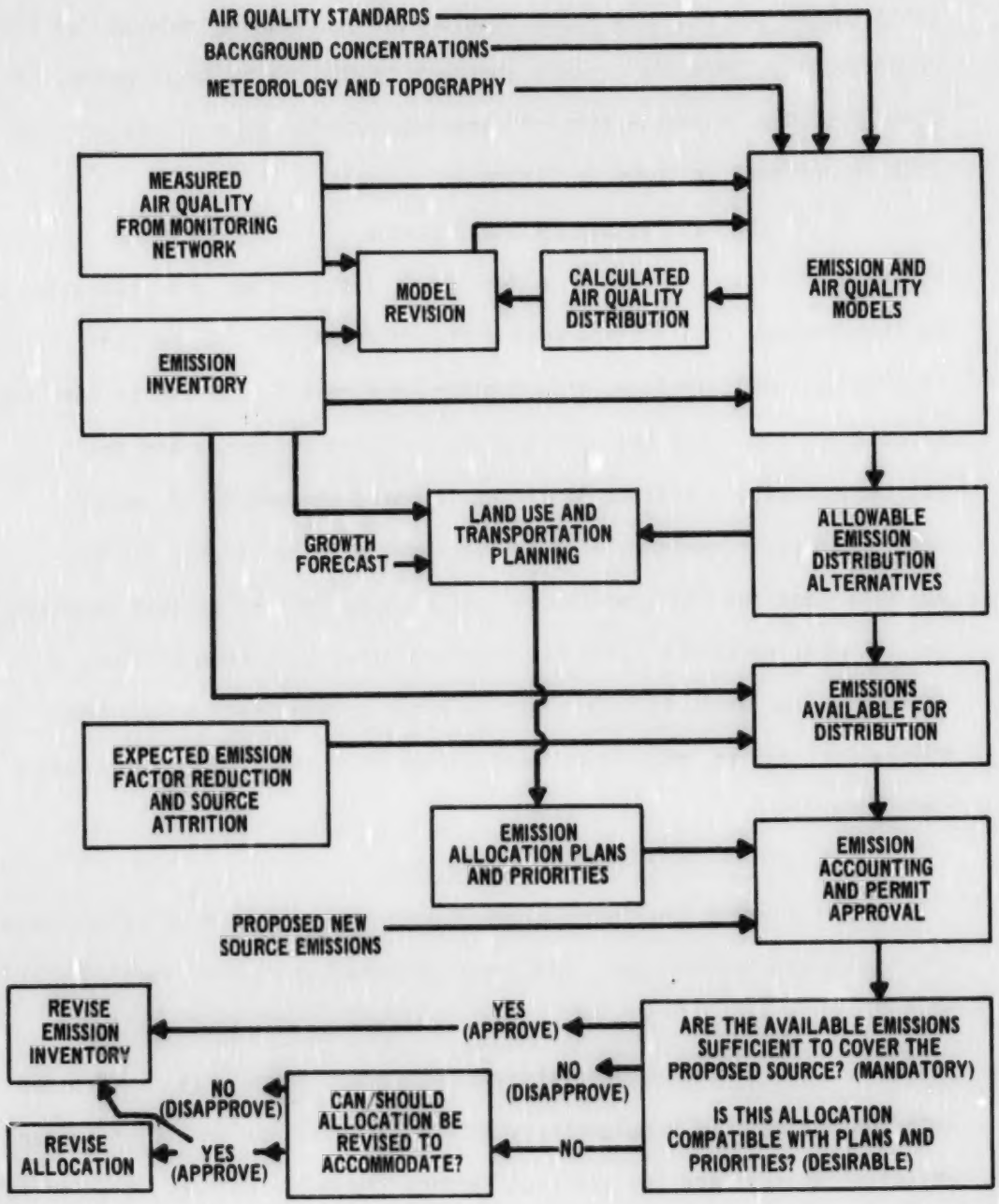
AIR QUALITY STANDARDS
BACKGROUND CONCENTRATIONS
METEOROLOGY AND TOPOGRAPHY
MEASURED AIR QUALITY FROM MONITORING NETWORK
MODEL REVISION
CALCULATED AIR QUALITY DISTRIBUTION
EMISSION AND AIR QUALITY MODELS
EMISSION INVENTORY
GROWTH FORECAST
LAND USE AND TRANSPORTATION PLANNING
ALLOWABLE EMISSION DISTRIBUTION ALTERNATIVES
EMISSIONS AVAILABLE FOR DISTRIBUTION
EXPECTED EMISSION FACTOR REDUCTION AND SOURCE ATTRITION
EMISSION ALLOCATION PLANS AND PRIORITIES
EMISSION ACCOUNTING AND PERMIT APPROVAL
PROPOSED NEW SOURCE EMISSIONS
REVISE EMISSION INVENTORY
YES (APPROVE)
ARE THE AVAILABLE EMISSIONS SUFFICIENT TO COVER THE PROPOSED SOURCE? (MANDATORY)
NO (DISAPPROVE)
NO (DISAPPROVE)
CAN/SHOULD ALLOCATION BE REVISED TO ACCOMMODATE?
IS THIS ALLOCATION COMPATIBLE WITH PLANS AND PRIORITIES? (DESIRABLE)
REVISE ALLOCATION
YES (APPROVE)
NO

Figure 1. Flexible air quality maintenance process.

routes and modes, growth policy, etc.). These tactics can be combined in endless ways to implement one or a mixture of AQM control strategies. The first three tactics are designed to limit emissions from individual as well as groups of sources. Atmospheric simulation models relating emissions to air quality are needed to assess the effect of such tactics in improving air quality. Depending on the type of source and the pollutants of interest, use of point, area and/or line source models may be required. The fourth tactic has the same objective as the first three, but it is more suitable for analysis using area source models. The fifth tactic is to take fuller advantage of atmospheric dilutive capacity and/or short term variations in that capacity. For such a tactic to be successful, highly reliable analytical techniques for meteorological prediction and source contribution estimation, as well as clear placement of responsibility for difficult control decisions and enforcement, are necessary. For these reasons, EPA policy has been to confine such tactics to isolated point sources. Nevertheless, urban sources should utilize stacks with heights as needed in accordance with "good engineering practice."[13] The sixth tactic includes those measures which influence the rate or pattern of emissions by affecting the type, pattern density and/or intensity of activity in the area. Land use and transportation planning clearly fit this category. Growth policy is also an indirect air quality control tactic. These tactics are indirect because they do not limit the amount or location of emission specifically. Industrially zoned land may be developed for any number of source types whose emission factors may differ

by orders of magnitude. The emissions from a transportation corridor depend on the mix of transportation modes employed. The emissions associated with a given population depend on the mix and pattern of the urban activities.

Land use and transportation patterns are nevertheless highly influential over the types of air quality control measures that can be practically employed. Conversely, the state of emission control technology limits the extent and intensity of certain land uses. For such tactics to be effective in maintaining air quality within defined limits, it is essential that analysis by the air pollution control agency be closely coordinated with the work of land use/transportation planners. The analysis performed by the control agency using models with locational inputs can be used to define a number of combinations of emission density limitations associated with numerous patterns of areas with differing land uses. Such a procedure should aid the planners in selecting sets of patterns which are consistent with maintenance requirements and are at the same time realistic and responsive to the area's social and economic needs.

3.5 Analysis of Proposed New Sources

All point and indirect sources of certain sizes and types should receive an air quality impact analysis prior to approval regardless of where they are located. The analysis for specific proposed new sources is necessary, because the reliability with which the assessment of the source's impact on air quality can be

made is greatly enhanced once the exact location, design characteristics (e.g. stack height, volume throughput for point sources, or peak expected demand-capacity ratios for indirect sources) and size of the source are known. Within an urban area, smaller and more types of proposed sources should receive more scrutiny than is necessary in undeveloped areas. If an area is operating under an AQM plan or process, all new emission sources should be subject to some kind of limitations on emissions, and/or location, but it is clearly impractical to subject each one to an air quality impact analysis. The restraints on small source development should be approached through design standards, emission density zoning, urban design, transportation planning or other collective means.

Analysis for larger point and indirect sources should include the following estimates: (1) the probable emissions created or induced by the proposed source, (2) the probable concentrations that would result from the proposed source's emissions, (3) the present and expected concentrations due to existing and expected new emissions in the area significantly affected by the proposed new source, (4) the sum of (2) and (3) for each relevant pollutant and averaging time and comparison with applicable air quality standards, and (5) (possibly) an estimate of the new emissions that could be permitted in the proposed location, or suggested locations where the proposed source could locate. Analytical techniques which might be used to estimate the impact of individual new sources are suggested in Volumes 9 and 10 in Guidelines for Air Quality Monitoring Planning and Analysis.[14,15]

4.0 FRAMEWORK FOR AIR QUALITY MAINTENANCE ANALYSIS GUIDELINES

Since there are several Volumes in the Guidelines for Air Quality Maintenance Planning and Analysis series which describe the various elements of analysis, the review and use of these documents is likely to be facilitated if their relationship to the analytical procedure described in this volume is enunciated. There are seven Volumes (Volumes 7-13) which discuss the elements of analysis in greater detail. Volume 7, "Projecting County Emissions," contains suggested methodologies for projecting future emissions of criteria pollutants for the county as a whole, starting with an updated, current emission inventory in an appropriate National Emission Data System (NEDS) format. Several levels of effort for making county-wide projections, with their attendant advantages and disadvantages, are discussed. Volume 8, "Computer-Assisted Area Source Emissions Gridding Procedure," presents one method which may be useful in allocating present and projected county-wide area source emissions within the county. The methodology described in Volume 8 may be particularly reliable for estimating distributions of pollutants which are closely related to living patterns, into the near (e.g. less than 5 years) future. Volume 13, "Sub-County Emission Allocation," is a more general treatment of rationales which might be used as bases for allocating projected county-wide area source emissions and, to the extent possible, projected point source emissions within the

county. Volume 11, "Air Quality Monitoring and Data Analysis," contains guidance concernig monitoring network design and instrument siting, acceptable instrumentation, air quality data evaluation procedures, interpretation of air quality data as it relates to NAAQS, establishment of baseline air quality levels and air quality trends evaluation. The information in Volume 11 serves as useful guidance for updating and improving air quality data bases. In addition, interpretation of air quality data in accordance with the guidance in Volume 11 will aid in the efforts to validate and/or calibrate reliable atmospheric simulation models. Volume 12, "Applying Atmospheric Simulation Models to Air Quality Maintenance Areas," discusses the data requirements needed by several categories of models. Such information can be of use in identifying the level of effort needed for monitoring meteorological variables in an area and in identifying key emission information which should have a high priority. Volume 12 also describes the spatial and temporal resolution available with various types of models, as well as the pollutants for which each type of model is appropriate. Examples of each type of model are cited and described briefly. Volume 12 can be used as a means for weighing the data requirements (and their attendant costs) of each modeling approach against the analytical capability afforded with each approach. An essential part of an air quality maintenance plan is the review of major new proposed sources. This requirement results from (1) the need to determine whether a proposed source is consistent with a prescribed maintenance

plan, and (2) the increased reliability of modeling techniques when specific locational, size and design information about a source is available. Volume 10, "Reviewing New Stationary Sources," and Volume 9, "Evaluating Indirect Sources," address the need for impact analysis of specific sources. Table 1 summarizes the roles of Volumes 7-13 in the analysis of air quality maintenance areas and in the formulation of maintenance procedures.

TABLE 1--ROLE OF ANALYSIS GUIDELINES IN ASSESSING THE NEED FOR MAINTENANCE PLANS AND IN PLAN FORMULATION

Volume Number	Functions
7	Project county-wide emissions to future years (out to 10 years). Projections can be made to simulate the "most probable" occurrence, or the "worst" of a set of county-wide projections.
8, 13	Distribution of emissions projected using Volume 7 within the county. Distribution can be made to simulate "most probable" distribution or the "worst" of a set of realistic distributions. Methods can also be used to distribute present area source emissions within a county.
11	Used as guidance for developing and maintaining a technically adequate air quality monitoring network and in interpreting data from this system properly. Such data can be used to validate and/or calibrate atmospheric simulation models.
12	Used to relate present and future emissions to present and future air quality under various meteorological conditions. Used to determine the set of emission development patterns which will meet NAAQS, and to prescribe emission limitations which should be met to ensure conformity with NAAQS.
9, 10	To evaluate the impact of a proposed source on air quality in its immediate vicinity. Used to determine whether a proposed source is consistent with maintenance requirements and as possible bases for granting or refusing to grant construction or operating permits.

5.0 REFERENCES

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(8) U. S. EPA, OAQPS; "Guidelines for Designation of Air Quality Maintenance Areas"; Guidelines for Air Quality Maintenance Planning and Analysis; Volume 1; OAQPS 1.2-016; (January 1974).

(9) U. S. EPA, OAQPS; "Projecting County Emissions"; Guidelines for Air Quality Planning and Analysis; Volume 7; OAQPS No. 1.2-026; (September 1974).

(10) U. S. EPA, OAQPS; "Computer-Assisted Area Source Emissions Gridding Procedure"; Guidelines for Air Quality Maintenance Planning and Analysis; Volume 8; OAQPS 1.2-027; (September 1974).

(11) U. S. EPA, OAQPS; "Subcounty Emission Allocation"; Guidelines for Air Quality Maintenance Planning and Analysis; Volume 13; (September 1974).

(12) U. S. EPA, OAQPS; "Applying Atmospheric Simulation Models to Air Quality Maintenance Areas"; Guidelines for Air Quality Maintenance Planning and Analysis; Volume 12; OAQPS No. 1.2-031; (September 1974).

(13) 40 CFR 51.13(h); "Use of Supplementary Control Systems and Implementation of Secondary Standards"; Federal Register; p. 25,700; (September 14, 1973).

(14) U. S. EPA, OAQPS; "Evaluating Indirect Sources"; Guidelines for Air Quality Maintenance Planning and Analysis; Volume 9; OAQPS No. 1.2-028; (September 1974).

(15) U. S. EPA, OAQPS; "Reviewing New Stationary Sources," Guidelines for Air Quality Maintenance Planning and Analysis; Volume 10; OAQPS No. 1.2-029; (September 1974).